10 DISCUSSION

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Discussion

Over the past several years assisted reproductive technology (ART) has started to attract the interest of politicians, policy makers, demographers and economists. After years of less than desirable media attention placed on assisted reproductive technologies, the good news and benefits regarding assisted reproduction have started to capture the imagination of a variety of different stakeholders.[1,2,3] Perhaps most importantly, politicians and various interested groups have started to realise that the benefits of ART not only passed directly to those couples being treated, but that these benefits increasingly influence society.

Despite the good news regarding ART conceived children, considerable variation exists in many European countries and North America with respect to reimbursement and fertility coverage.[4] Increasingly it is recognised that funding and reimbursement are some of the major factors influencing access to care and without reimbursement many couples are unable to afford care.[5] The relatively high cost for ART procedures means that reimbursement of services is an important element in ensuring delivery of care.[6] Previous investigations have described the relationship between ART reimbursement and annual per capita treatment cycles in different countries.[7,8,9]

Affordability and cost constraints can also influence clinical practice and treatment choices made by consumers. Data from the US has demonstrated that insurance coverage influences the number of embryos transferred and consequently multiple birth rates leading to increased healthcare costs.[10] In a survey of family growth in the US the impact of income and insurance status on access to different levels of fertility service provision were assessed. The investigators noted that seeking advice (i.e. consultation) for infertility was

the only fertility service that was not influenced by either insurance status or income level.[11] The investigators also noted that insurance coverage increased the likelihood that women would pursue treatment with medications only or with surgery compared with 'no treatment' observed with uninsured women. A trend showing that low income women were more likely to pursue the 'no treatment' option was also observed. Additionally, for low income women there was only an 11% chance they would pursue ART. In contrast high income women were almost two-times as likely to pursue the ART treatment option.[11]

Discussion Part II

In **Chapter 2** we attempted to capture the consumer interests in relation to costs for in-vitro fertilisation (IVF) using search query data entered into Google search engines in the United States (US) and the United Kingdom (UK). As a hypothesis generating exercise we explored changes in internet search volumes using the search terms "cost + IVF" and "costs of IVF." Based on the timeframe explored we observed an increase proportion of Google searches in the US using cost terms associated with IVF. Furthermore, Google searches using cost related terms were predominantly concentrated in those states without legislated mandates requiring that insurance companies practicing in those states provide some level of fertility coverage. Because couples in states without mandates would be required to pay for treatments out of pocket this might suggest increased concern amongst couples regarding costs, therefore explaining increased internet searches including the 'cost' terms.

The influence of costs faced by consumers on the demand for IVF and ICSI was explored by taking advantage of a natural experiment involving changes to fertility funding policies in Germany requiring that couples pay 50% of treatment costs. In **Chapter 3** we estimated the price-elasticity of demand associated with introducing a co-payment that ranged between €1,500 – €2,000 for IVF and ICSI in Germany. We found demand for IVF and ICSI to be relatively inelastic with price-elasticities of –0.41 and –0.34, respectively.[12] Based on the reported elasticities this might suggest that a 10% increase in price reduces utilisation by 4.1% and 3.4% for IVF and ICSI, respectively. Cross-price elasticity assessment of clomifene which are often used prior to IVF and ICSI indicated that patients didn't switch to low cost, low efficacy interventions following introduction of the co-payment.

The results described in **Chapters 2 & 3** support previous observations that costs faced by consumers are important with respect to accessing reproductive treatments.

Discussion Part II

Increasingly assisted reproduction is discussed in the context of ageing populations and the influence of reproductive technologies on future demographic structures.[2,3,13,14] Traditionally the focus of demographic research has been to understand factors that influence fertility patterns, while often dismissing the impact of infertility on birth rates. However, increasingly research has started to focus on what can be considered the '*willing but unable*' members of society that are infertile and unable to reproduce naturally. With estimates as high as one in seven couples experiencing infertility and projections that these figures are likely to increase, it would appear that '*willing but unable*' couples are increasingly of interest to demographers.[15,16] If reproductive treatments were viewed in the context of population policy, as they are in a limited number of countries, then policies that limit access would have an opportunity cost from prohibiting infertile couples from being treated.[17,18] The research described in **Chapters 4, 5, & 6** sought to better understand the opportunity cost of IVF treatments by estimating the lifetime net tax contributions attributed to an IVF conceived child.

The Lifetime Net Tax (LNT) models described in **Chapters 4 – 6** outline the economic benefits for government in future taxes that can arise from investments in IVF technology applying a 'government perspective' in the analysis. The methodology deviates from typical healthcare evaluations which seldom consider taxes generated from healthcare interventions. Typically economic evaluations of medical technologies ignore taxes because they are considered a transfer between individuals and consequently excluded from economic evaluations that are conducted from the societal or health service perspective. Within the government perspective framework described in **Chapters 4 – 6** we accounted for future tax revenues paid by an IVF conceived child. Previous claims regarding the economic value of IVF conceived children have been made by others, however to the best of our knowledge these claims were not substantiated using a rigorous methodology as those described here.[19,20,21]

The inclusion of taxes in a government perspective model for valuing IVF outcomes is thought to be appropriate because taxes are often the main source of revenue for many governments.[22] Furthermore, because many governments are concerned about sustainability of public finances – especially in light of ageing populations and falling birth rates – it was felt that the inclusion of these costs could assess whether public subsidy of IVF represents a good use of tax-payer funds. Conceptually and methodologically, our approach is comparable with generational accounting methods regularly used by national treasury departments, including Her Majesty's Treasury, the

European Commission and the World Bank.[23] Generational accounting is used by these organisations for long-term fiscal planning to establish whether there is generational imbalance between fiscal promises and current and future tax payors available to pay for these promises. Fundamental to conclusions drawn from generational accounting models is the role of our changing demography and how many children will be around in the future to pay taxes to support an ageing population. As demography underpins generational accounting principles, we considered that the increasing proportion of live births each year attributed to assisted reproduction, up to 4% of national births each year in some countries, warranted investigation to assess the long-term economic contribution of all these children who would not have been born if the technology were not available.[24,25]

The three studies based on the Lifetime Net Tax (LNT) model discussed in **Chapters 4 – 6** demonstrate consistently that public subsidy in IVF represents a positive return on investment. In the three models we explored variations in the IVF costs per live birth showing a consistent return on investment. A summary of the key findings from each of the three studies are presented in Table 1

The three studies described in **Chapters 4 – 6** highlight the opportunity costs to government attributed to treatment barriers that prevent people from accessing reproductive treatments. Regardless of the barrier (e.g., reimbursement, limited funding, embryo transfer legislation), there is an economic consequence of preventing people from accessing the care they need. When these barriers are positioned within the ageing population debate within many countries it is easy to appreciate the importance of these findings.

The three studies estimating future net tax revenues generated from IVF conceived children described here share a similar analytical framework based on generational accounting.[23,26] Because the aims of the analyses described in **Chapters 4 – 6** were identical and the analytical framework is similar it is tempting to compare the results from the studies. While cursory comparisons can be performed there is nothing revealing about IVF technology from such a comparison. In fact, each model is unique because it reflects the social and individual lifestyles in each of these countries and differences in human capital investments made by each government. These differences in human capital investments and economic conditions are ultimately reflected in the end results for each country.

It is likely that the IVF LNT model results reveal something intuitive about the relationship between governments and their citizens. Our investigations show that on average, the state stands to gain more in future taxes by funding

Table 1 Comparison of IVF government perspective models

Country	Key findings	Citation
United States	Lifetime discounted value of net taxes from an IVF conceived child is $155,870 The discounted return on investment for government would be 7-times the original IVF investment costs Lifetime net tax contribution is US $606,200	Connolly, American J. Managed Care (2008)
Sweden	Lifetime discounted value of net taxes from an IVF conceived child is 254,000 SEK An individual born in 2005 will pay an undiscounted 32.5 million SEK in taxes to the Swedish government State-funded IVF in Sweden does not negatively impact on the long run fiscal budget	Svensson, Scand J. Public Health (2008)
United Kingdom	Lifetime discounted value of net taxes from an IVF-conceived child is £109 939 Return on investment is 8.5-times IVF investment costs in present value Lifetime undiscounted net tax contribution is £603,000	Connolly, Human Reproduction (2009)

fertility treatments than average lifetime financial transfers made to any individual. This was the case for both a naturally conceived child and the IVF conceived child and there is no reason to believe the life course of these children would be any different. In the LNT model government stands to lose when individuals live beyond normal life expectancy and when governments promise more in financial transfers than expected tax receipts. Generational accounting models help governments to understand the relationship between fiscal promises and projected future tax receipts over many receipts. On the whole governments normally aim to bring in more in taxes per citizen than average fiscal promises to each citizen unless the majority of government revenue is generated from non-tax receipts. In the three studies described in **Chapters 4 – 6** we demonstrate an average tax surplus per citizen. This is not necessarily considered profit for the state; rather the excess revenue allows governments to invest in other policies to achieve social and political aims.

The LNT models described here are thought to offer several advantages over typical economic evaluations applied to healthcare interventions. Firstly, outcomes are defined purely in economic terms that are easy for people to grasp. The ability to translate fertility outcomes in economic terms seems particularly relevant to communicate the advantages of reproductive technology to a range of stakeholders outside of the health service. Furthermore, as discussed in **Chapter 1**, the QALY is likely inappropriate for valuing outcomes attributed to the resulting child from successful application

of reproductive treatments. Interestingly, if QALYs were applicable for valuing resulting years from an IVF conceived live birth they would likely represent an exceptionally low cost per QALY.[20]

The investigations described in **Chapters 4 – 6** also help to underscore that to adequately value IVF programs and the resulting children requires a longer time horizon and a more comprehensive consideration of costs than normally occurs with typical economic evaluations. In fact, we have shown that the return on investment from public subsidy can take more than 30 years, but the investment does pay dividends for the state even when discounted using treasury department rates. Furthermore, because we adopted a government perspective in the analysis it was necessary to include a comprehensive assessment of costs that does not occur with most health technologies. For example, we included future medical costs for the IVF conceived child in the analysis. While health economists debate whether future costs should be included in economic evaluations we felt it was necessary to include these costs to account for future government expenditure that will arise following public subsidy of fertility treatments and the resulting birth.[27]

Several criticisms could be made against the LNT model described in **Chapters 4 – 6**. For example, we previously received criticisms for failing to consider additional costs attributed to over-population and the environmental impact of an additional child in our analysis. This is a valid point although limited information is available regarding the economic impact of one additional child.[28] Although it is also important to recognise that the inclusion of these costs would not be specific to an IVF conceived child and would be equally applicable to a naturally conceived child. The approach has also been criticised for not considering indirect costs attributed to the female undergoing treatment and time off from work. However, these costs are known to be insignificant and had we included them they would no influence the conclusions drawn from our studies.[29]

Based on projected future tax contributions from an IVF conceived child off-set against direct lifetime government fiscal transfers we can conclude that investing in IVF yields a positive return on investment for governments. The LNT model results described here are based on the average costs to conceive a child using IVF and the resulting lifetime net tax contributions. Extending these figures to a cohort of children born every year from reproductive technology the benefits are easily worth billions of dollars in future tax revenue every year. The results described here most likely underestimate the macroeconomic benefits of ART conceived children because it only focuses on net tax revenues to government and does not considered the broader benefits of an individual on economic growth. The economic framework for

evaluating IVF treatments described here suggests that the opportunity cost of rationing fertility treatments has yet to be fully appreciated in resource allocation decisions in many countries.

Discussion Part III

The need to maximise outcomes with available scarce resources using economic evaluations has become an important element of healthcare delivery as demand for health services outstrips available supply. This is particularly relevant for fertility treatments because of the high costs of ART treatments and limited reimbursement resulting in the need to ration treatment using social and clinical criteria.[30] Because of the need for efficiency in health systems, the availability of economic evaluations comparing treatment alternatives can aid decision-making to identify treatment strategies that optimise birth rates with the limited resources available, thus enabling more people to be treated within a fixed budget.

The results described in **Chapters 7 – 9** in three separate analyses and in two different countries have consistently shown that human derived highly purified gonadotrophins (HP-hMG) are more cost-effective compared with recombinant FSH (rFSH). This conclusion is based on the cost per live birth derived for HP-hMG and rFSH based on three separate sets of randomised controlled data. In fact, the results illustrate using randomised controlled trial data that more live births can be obtained at a lower cost using human derived hMG compared with rFSH.

Economics evaluations of fertility treatments are unique compared with normal cost-effectiveness analyses requested by decision-makers where QALYs are often the preferred outcome.[31] In the delivery of reproductive treatment there is little doubt that the outcome of interest is live births. Regarding the selection of outcomes for economic evaluations of fertility treatments Gleicher suggested that "*anything else [i.e. other outcomes] is self-defeating in its incentives and deceptive in its accuracy of cost assessment.*"[32] In many respects the use of live birth rates simplifies cost-effectiveness analysis because of ease of establishing treatment outcomes between comparative treatment options. Because of this the outcome mostly used in economic evaluations is the 'cost per live birth' or 'cost per take home baby.' Occassionally economic studies will report the 'cost per ongoing pregnancy.' However, this represents an intermediate outcome and can be misleading because there is no guarantee the child will make it to full term resulting in a successful live birth. The economic evaluations reported here used what is likely the most appropriate outcome for fertility treatments where we report the 'cost per live birth' between different gonadotrophin treatment preparations.

A critical element in all cost-effectiveness studies is the timeframe over which costs and outcomes are considered. With respect economic evaluations this suggests the need to include maternal and neonatal costs that arise following different treatment interventions.[32] In economic evaluations of different embryo transfer policies the inclusion of maternal and neonatal costs has been critical for making informed policy choices and resource allocation decisions regarding the number of embryos transferred per cycle.[29,33,34] However, when comparing different gonadotrophin treatments the inclusion of maternal and neonatal costs after a single IVF cycle will increase total costs for the intervention that achieves a higher live birth rate which could lease to spurious decisions regarding resource allocations.

Of the available studies comparing gonadotrophins in economic evaluations there is no consistency regarding the inclusion of maternal and neonatal costs in the denominators of the cost-effectiveness ratio.[35,36] Of the three economic evaluations reported in **Chapters 7 – 9**, two of the studies included maternal and neonatal costs (Chapters 8 & 9)[37,38] and one study did not include maternal and neonatal costs (Chapter 7).[39]

From our experience both including and excluding maternal and neonatal costs, it is likely that the inclusion of these costs are mostly applicable when comparing interventions that have different multiple pregnancy rates. The justification for this is that if multiple pregnancies are comparable, then including maternal and neonatal costs will have little bearing on the results. However, if the aim of the analysis is to compare different multiple pregnancy rates then these costs should be included in the total cost calculation because this is likely critical to the question being addressed in the analysis. On the other hand if multiple pregnancy rates are comparable then they aren't likely to influence the findings of the study. In the studies that included maternal and neonatal costs we found that their inclusion in the analysis did not influence the main findings.[37,38] In both studies that we evaluated the multiple pregnancy rates were comparable which explains why including the maternal and neonatal costs did not alter the findings.

Increasingly technology appraisal agencies ask that comparative cost-effectiveness analysis includes probabilistic sensitivity analysis (PSA) to reflect imprecision of the input variables with results presented using cost-effectiveness acceptability curves (CEAC).[40,41,42] The CEAC can be used to plot the probability of being more cost-effective for competing interventions based on accepted standards of cost-effectiveness in a particular country. Because there are no fixed standards regarding the maximum willingness to pay (WTP) for a unit of health, most often measured using QALYs, it is common

to present the probability that each intervention is cost-effective over a range of WTP values. By plotting probabilities over a range of WTP thresholds this enables decision-makers to decide how much they are willing to pay per unit of health gain (e.g., QALY, life-year) in a particular condition and select the treatment with the highest probability of being cost-effective.

In fertility treatments where the outcome is measure using live births, the ability to use CEACs is somewhat hampered because the probability of producing a live birth is plotted over a range of different thresholds. In order to use CEACs decision-makers require some prerequisite or knowledge regarding how much they are likely to pay for a particular outcome. In the case of fertility treatments a decision-maker would need to establish how much they are willing to pay for an additional live birth. Because this would likely fall outside of the realm that decision-makers normally operate where decisions are based on QALYs or life-years, the CEAC is unlikely to be of much value because of lack of precedence regarding the value that society places on an additional child.

The results presented in **Chapters 7 – 9** can aid resource allocation decisions made by physicians, patients and health purchasers. However, it is important to recognise that these findings are by no means static. The important thing to recognise about economic evaluations is that the results reflect the costs and outcomes under a particular set of circumstances. If any factor were to dramatically change, for example the timeframe, the country, or patient group, this could just as easily influence the conclusions described here. One area where treatments are changing rapidly is in the adoption of low stimulation gonadotrophin protocols. As described by Noorashikin *et al,* the use of low dose stimulation protocols is equally effective while reducing treatment costs.[43] Because the results described here are based on high dose stimulation protocols it is conceivable that were the two products compared using different dosing protocols different results may have been obtained. At present this question can't be addressed until more widespread acceptance and use of low stimulation protocols occurs.

The point discussed above about changing dosing regiments illustrates the fact that as treatment practices evolve, a gap often exists between clinical evidence and informative economic evaluations to establish whether new practices are cost-effective. Evolution of new innovative practices is both welcome and should be encouraged, however efficacy data always precede economic studies, and new practices that are not cost-effective can become established as best practice even before cost-effectiveness data becomes available to inform questions of technical efficiency. As new technologies

evolve it would be of value to start considering cost-effectiveness decisions in advance and closing the gap between product launches and availability of results of high quality economic studies in order to inform treatment decisions rationally. In some instances economic studies can be performed on products in the development stage to inform necessary efficacy thresholds required to achieve current cost-effectiveness standards. In reality this practice rarely occurs and in many situations could impair innovation as it may kill new innovations in their infancy before the full extent of a products efficacy had been established.

Discussion Part IV - Broader application of research findings

The health investment model based on future tax revenues described in **Chapters 4 – 6** demonstrates how investing in reproductive technology such as IVF could have positive fiscal implications for governments – especially in light of ageing populations and concerns over sustainability of public finances. However, there is no justification for why the LNT methodology for estimating future taxes described in these chapters should be limited to valuing outcomes attributed to reproductive treatments. In this section we discuss the 'government perspective' health investment framework described in this paper more broadly and consider its role in influence healthcare priority-setting and resource allocation decisions.

Ageing populations and economic growth

Over the past several decades demographers have repeatedly described the ageing of populations in industrialised countries resulting from increasing longevity and falling fertility rates experienced over the past century.[44] While the accomplishments of humankind to increase life-expectancy and avert famine as predicted by earlier demographers should be applauded, ageing populations pose numerous challenges for all of us – most notable of which includes the shrinking numbers of working aged people expected to pay for social programs. As populations age and increasingly place demands on government funded social programs, few easy policy options are available and often includes cuts to public spending, increasing taxes to pay for increasing demand and in some instances both.[45,46,47] In many European countries old-age dependency ratios are expected reach 50% by 2050 whereby two working aged people will be supporting one person over the age of 65 compared with the current ratio of four working aged people to one retired person.[45]

As the number of working aged people starts to decline macroeconomic theory suggests growth will start to decline. Increases in physical capital (i.e. infrastructure, technology) and productivity can partially mitigate the effects of ageing populations.[48] However, to maintain living standards the

rate of productivity increase will need to be greater than the effects of ageing. This increasingly looks unlikely considering that productivity growth has been declining in many parts of Europe over the past two decade.[49,50] Labour market reform that encourages people to work longer and delay retirement has also been put forward as one potential option. However, as illustrated by Manton *et al*, increasing the age of retirement is only feasible provide people are healthy enough to remain working.[51]

Health as an investment

Few people question the positive correlation between health and economic growth that serves as the cornerstone of development economics, although the direction of the relationship is often debated. The traditional belief has been that wealthier nations have more command over healthcare resources and as a consequence were healthier. However, gradually this view has changed and health as an important economic determinant has become recognise.[53] Perhaps one of the best known examples is the relationship between life-expectancy and economic growth.[54,55] However, the relationship is more than simply keeping people alive for longer, but also recognises that economic growth is driven by the healthy that are able to supply labour to the market.[56,57,58] Therefore, the manner in which health influences labour force participation, labour productivity, creativity, and the absolute number of hours on the job can influence economic outcomes that should be considered when evaluating medical programs and setting priorities.

The principles of health and wealth have long been championed by organisations such as the WHO. More recently these ideas have caught on in Europe as outlined in an independent European Commission report published in 2005 where it was noted that "*policy-makers who are interested in improving economic outcomes (e.g. on the labour market or for the entire economy) would have good reasons to consider investment in health as one of their options by which to meet their economic objectives.*"[59] The authors of the report acknowledge that the subject is often overlooked in wealthier nations, while highlighting the importance of investing in health to achieve economic growth in the context of ageing populations.

The relationship between health and economic outcomes is based on human capital theory and that individuals invest in themselves to improve their economic condition.[60] Human capital takes many form but is often thought of in terms of knowledge, skills and experiences, but also includes investments in health. Much of the early human capital work was conducted by Becker to explain monetary returns from educational attainment where he touched on the subject of health.[61] Building on these ideas Grossman

described the demand for health from a microeconomic perspective using the ideas of human capital where he define health both as consumption good and as a capital good.[62] According to Grossman health as a consumption good makes people feel better, and health as a capital good health can enhance an individual's earning capacity.

An appreciation of the relationship between health and economic outcomes can also be gained by exploring the drivers of macroeconomic growth often defined in terms of gross domestic product (GDP). Numerous models have been developed to describe economic growth, however one of the better known models was developed by Robert Solow where he defined the key determinants of economic growth in terms of: technological progress (A) capital (K), and labour supply (L).[63] According to the Solow model for which he was later awarded the Nobel Prize, economic growth can only occur if there is an increase in either A, K, or L.

Although the Solow growth model does not specifically address human and health capital, it is know that health can directly or indirectly impact each of the inputs known to influence economic growth.[64] For example, health can influence both the supply of labour in terms of quantity and quality (L). Health also influences educational attainment and creativity which undoubtedly influences technological progress (A).[65] Furthermore, the relationship between improved health and longevity is believed to increase the personal savings rate as people expect to live longer.[53] Consequently an increased savings rate makes more money available for investing in physical capital which in turn influences economic growth.

Beneficiaries from investments in health

If health has economic value it is worth considering who benefits from improved popu lation health. At the individual level it is clear that persons experiencing health improvements regardless of whether measured in terms of reduced pain, increased quality of life, or economics are the beneficiaries. When health improvements occur at the aggregate level things are much different with a wider range of beneficiaries across society. This takes into consideration both aggregate measures of health but also the externality of poor health that can have consequences even for healthy individuals; especially in relation to communicable diseases. On the whole it is clear that as population health improves then society as a whole will benefit from health status improvements and accrue economic benefits.

Moreover, if health has an economic value then this value will surely be taxed. This point seeks to acknowledge that governments also benefit from economic

growth regardless of the causes. As economies expand, whether brought about through natural growth, economic stimulus or improved population health, all things being equal governments can benefit from increased tax revenue that results from economic expansion. This seemingly benign point is important in light of concerns over tax funded social programs and a shrinking tax base, and at a practical level could potentially be used to influence government resource allocation decisions in healthcare in the same way that governments currently invest in technologies and education to stimulate growth.

Popular belief often suggests that governments can increase tax revenue by increasing rates of taxation, however this is not necessarily supported by the empirical evidence whereby economic growth is thought to be a more effective for increasing tax revenue. Past studies have shown that increasing tax rates can have limited impact on tax revenue as higher tax rates increase incentives for misreporting and increases demand for leisure time. This point is illustrated from an analysis in the US which shows that changes to the highest marginal tax rate between 91% and 35% over 40 years did not significantly impacted government tax revenue as a percent of GDP.[66] Supply-side economists make the case for lowering taxes to stimulate economic growth as a more efficient means for governments to increase tax revenues.[67] The relationship between economic growth and increasing tax revenues has also been noted in Congressional reports in the United States.[68]

Applying the growth and tax perspective to health highlights that governments, especially those with tax funded health systems, might be better positioned to influence tax receipts based on how resources are allocated within the health service. There is nothing sinister about the relationship and simply acknowledges that a small component of the economic growth attributed to health gains described earlier will be collected in the form of taxes as economies expand.[51,59,66] The relationship between health and tax receipts for government can work in the opposite direction as recently acknowledged in a report from the WHO on the economic consequences of disease and injury.[69] Moreover, investing in programs that enable people to work longer into retirement, avoid short and long-term sick leave or avoid illness altogether, increase productivity will stimulate economic outcomes for individuals but can also benefit government both in terms of increased tax receipts and reduced demand on publicly funded programs.

Tax value of a life

As previously described in **Chapters 4 – 6** the LNT model treated IVF costs to conceive a child as an investment with future economic consequences. In the US, UK and Swedish LNT models we demonstrated that from the government

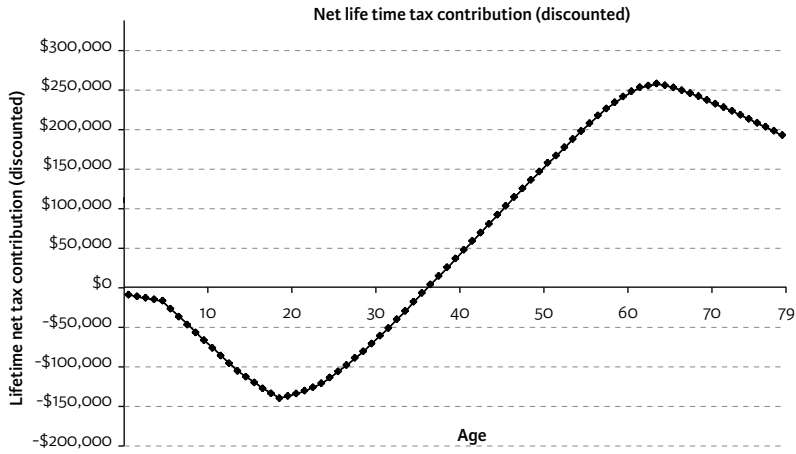
perspective there is a strong case for public subsidy of fertility treatments in these countries.

The LNT model is a useful and straightforward tool for evaluating fertility treatments because live births achieved ultimately lead to an increase in the supply of labour. However, for the LNT methodology to be relevant to healthcare decision-makers it needs to be more broadly applicable to a range of medical interventions. While it is true that fertility treatments do influence the supply of labour, the same could be said for any medical intervention that saves a life or enables a person to work longer or more efficiently. In economic terms, investing healthcare resources to create a life using IVF or investing resources to save a life or improve the productivity of an individual are analysed using the same methodological framework for valuing human life using labour wage rates.[70] Whether you save a life or create a life by investing healthcare resources, the end result is the same because there is one additional person alive who would not have been alive if decisive medical care to save or to create life had not been taken.

When population health is viewed in the context of ageing populations the relevance of health investment models like the LNT model described in **Chapters 4 – 6** become more apparent. The demographer Phillip Longman writing on the subject of ageing populations suggested that "With a shrinking labor supply, Europe's future economic growth will therefore depend entirely on getting more out of each remaining worker (many of them unskilled, recently arrived immigrants), even as it has to tax them at higher and higher rates to pay for old-age pensions and health care." [71] From this perspective it is possible to see the relevance of the LNT model and how it can potentially be applied to a wider range of different interventions. In particular those medical interventions that have the capacity to significantly influence absenteeism, presenteeism, withdrawal from the work force and premature death.

It is important to recognise that the LNT model described in **Chapters 4 – 6** is not an economic evaluation like those used by HTA agencies. Because it emphasises tax benefits attributed to improved health status or reduced mortality the method places no value on the commodity of health, consequently it undervalues the benefits of improved health status from the societal perspective. The approach solely focuses on individuals as economic entities and how health status improvements can influence the manner in which future economic activities take place. In this respect the health investment model addresses a fundamentally different question and considers the costs and consequences of changes in population health on government accounts. This approach may be useful for evaluating other

Figure 1 Lifetime fiscal balance sheet between an individual and US government over projected lifetime based on US government financial transfers and project average earnings and longevity



technologies because it addresses medical intervention costs in relation to increased productivity and sustainability of public finances (i.e. tax revenue) in the same analysis.

Resource allocation and returns on investing in health

The findings described in **Chapters 4 – 6**, although in many respects intuitive, can be used to contrast differences between where healthcare resources are commonly spent and where tax revenues are generated. To illustrate this we reproduce a figure from our previous work (Figure 1). The trace in Figure 1 illustrates the lifetime cash flow between an individual and their government. In the early stages of life an individual is a net recipient of government transfers. After entering the work force financial transfers flow in favour of government as workers start to pay taxes (eg, income taxes, consumption taxes, property taxes and levies). Finally, when individuals exit the work force they transition to a stage of reduced tax contributions while increasing demand on public services (e.g., healthcare, pension, and social services).

In comparison several studies have reported that healthcare consumption and costs are often concentrated in the elderly and younger children.[72,73] Because the need is higher in these groups, and in particular older persons, current spending simply reflects demand. However, when age-related spending is viewed in the context of the LNT these two groups represent extreme ends

of the economic lifecycle wi th entirely different returns on investment from health expenditure. This simply reflects differences in future economic capacity between different age groups. Perhaps the more important question to ask is whether current spending in one age cohort is done to the detriment of another age cohort. Furthermore, is it possible to achieve the same level of health gain, while also influencing future tax revenues in a positive direction.

Priority setting and resource allocation decisions are influenced by a range of factors that includes medical need, defined in various different ways, equity, and increasingly QALYs. If health services seek to influence economic outcomes then it is conceivable that remaining economic capacity might need to be considered in priority setting in the future. In this respect the LNT approach that we have described can help to answer questions about how investing in programs influences economic outcomes. Although the model we developed has been used to assess fertility treatments, it can easily be adapted to evaluate almost any intervention. In particular those with an acute intervention cost and clearly definable outcome, for example vaccination programs that save lives or surgical interventions that influence future work capacity. However, it needs to be emphasised that this approach should never be used in isolation to influence resource allocation decisions. Rather, it can be used in conjunction with existing criteria for priority setting. Perhaps it is most useful for pointing out some fairly glaring facts about where resources are allocated or aren't being allocated as in the IVF case.

The major weakness in applying the LTN in decision making is that one might always favour the young and working over the old and not working. The allocation of resources based purely on remaining economic capacity is no doubt deplorable for many. However, in fact precedence already exists for priority setting that favours the young. Previous public assessments have shown that in the allocation of life saving treatments the public often favour allocating resources to the young compared with the old.[74,75] The rationale for why public opinion should favour the young over the old is often not explicit but is thought to be on moral grounds and remaining life-expectancy. Whilst claims over resources for the young are often made on moral grounds, the LTN provides an economic rationale for allocating resources in this manner.

Conclusions Part IV of Discussion

To many readers allocating resources on the basis of economic benefits or future revenue for government is a ghastly prospect on which to base disease prioritisation and treatment decisions. On the other hand we know that sustainability of public finances, economic growth and maintaining living standards are also important for society. The options for maintaining

all of these societal values will be challenging as the number of working aged people decrease at the same time that demands on publicly funded programs. For many nations difficult decisions will have to be made in order to maintain economic growth, deliver generous health and social programs, while balancing how much they intend to tax current and future generations.

In reality every element of the ageing population problem and all of the possible solutions should not be seen in isolation of one another. If nations can use their health service to improve economic sustainability in the face of ageing populations then it might be in their interests to do so. Particularly if the economic rewards of growth are shared amongst all members of society. This suggests there might be a need to take resources away from some health programs and allocate them to programs that offer better economic prospects. But, if all members can share from the economic benefits then it is still possible to maximise societal welfare in doing so. Conversely, to ignore opportunities for achieving growth by using the health service seems equally objectionable.

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